Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

EFFECTS OF EIGHT-WEEK WHOLE-BODY VIBRATION TRAINING ON POSTURAL STABILITY IN ELDERLY ADULTS

Wei-Hsiu Lin[1], Jun-Dar Lin[2], Yen-Ting Wang[3] and Alex J. Y. Lee[1,2]

Department of P.E., National ChiaYi University,Taiwan[1]
Department of P.E., National HsinChu University of Education,Taiwan[2]
Graduate Institute of Coaching Science, National Taiwan Sport University, Taiwan[3]

The aim of this study was to examine the effects of an eight-week whole-body vibration training (WBVT) on postural stability (PS) in elderly people. Twenty-two elderly people with normal ability of movement were randomized into the WBVT group (WBVTG, 13 elders), and the control group (CG, 9 elders). The WBVTG underwent WBV training for 8 weeks. The CG did not take any physical training. The PS performance was evaluated by the Biodex Balance System to measure the overall (O), anterior-posterior (AP), and medial-lateral (ML) stability at level 2 (unstable) and level 8 (stable). One-way ANCOVA were used for statistical analysis, with α=0.05. Results showed that after training, the WBVG significantly improved the O, AP, and ML stability performance at level 2, and also the O and ML stability performance at level 8.

KEY WORDS: balance control, sensorimotor function, ageing.

INTRODUCTION: Ageing is associated with the deterioration of the neuromuscular and sensorimotor function, which might affect physical activities and postural stability (PS) during the daily life. PS has been defined as the ability to maintain an upright posture in a weight carrying position without falling and to keep the center of gravity within the limits of the base of support. It is also defined as the act of maintaining, achieving, or restoring a state of balance during any postural disturbance or physical activity. The center of pressure is the application point of the resultant of the ground reaction forces and can be calculated from the ground-reaction forces projected from the body which is easily recorded with a force platform. It reflects the trajectory of the body center of mass and the amount of torque applied at the support surface to control body-mass acceleration (Lee & Lin, 2007; 2008).
Whole body vibration (WBV) is a new biophysical modality to provide systemic vibration signals for mechanical stimulation and has recently emerged as an exercise intervention that can have positive effects on the neural, muscular and skeletal systems. WBV exercise involves standing on a platform that oscillates at a particular frequency and amplitude, which activating muscle contractions via stimulation of sensory receptors (Cardinale & Lim, 2003). WBV was reported to improve vertical jumping height, muscular contractile properties, and muscle strength in healthy young adults, and improved the neuromuscular performance such as the 5-Chair Stands test, the Timed Up and Go test, and the Tinetti test of community-dwelling older adults (Furness & Maschette, 2009). Because of the poor muscular performance and low bone quality, the benefits of WBV on PS in the elders are still uncertain, which may be dependent of age and physical conditions. Therefore, the purpose of this study was to examine the effects of an 8-week WBV exercise program on dynamic PS in the elders.

METHODS: Twenty-two elderly people with normal ability of movement were recruited and randomized as the WBVT group (WBVTG, 13 elderly people, Age: 66.8 ± 6.2 years old; Height: 162.2 ± 6.4 cm; Mass: 62.9 ± 8.3 kg), and the control group (CG, 9 elderly people, Age: 70.4 ± 8.2 years old; Height: 159.3 ± 7.6 cm; Weight: 63.9 ± 9.8 kg). The inclusion criteria were being age 60 years or older, and able to stand independently without any aids. The exclusion criteria were (1) having any hormonal replacement therapy or drug treatment that could affect normal metabolism of musculoskeletal system; (2) having any hypo- or hyperparathyroidism, renal, liver, or chronic disease; and (3) having habitual exercise or participate in any supervised exercise. All participants agreed not to change or increase their usual exercise habits during the period of the study. Participants were excluded if their activity habit had changed during the study period. The study was approved by the ethics committee of the university, and informed consent was obtained from all the participants before enrollment into the study.

Participants in the WBVT group were asked to receive all the treatments 3 times a week for 8 weeks in bare feet throughout the study in two community centers in HsinChu, TAIWAN. The WBV was performed by using the DKN Extreme PRO (Belgio, Taiwan), which is a vertical vibration device with amplitude of 2.5 or 5 mm and a variable frequency of 30 to 45 Hz. The amplitude and frequency were controlled by adjusting the setting from the top panel, with the larger the number, the greater the acceleration. Before the training, procedures, guidelines, and its safety issues were presented to the participants both orally and in written form by the research assistant. Participants performed static and dynamic knee-extensor exercises on the vibration platform: squat, deep squat, wide stance squat, one-legged squat, and lunge. Training load was low at the beginning but progressed slowly according to the overload principle. The training volume increased systematically over the training period by increasing the duration of one vibration session, the number of series of one exercise, or the number of different exercises. The training intensity was increased by shortening the rest periods or by increasing the amplitude (low, 2.5 mm; high, 5.0 mm) and/or the frequency (30–45 Hz) of the vibration. In addition, training load was increased by changing the execution form of the exercises from predominantly two-legged to one-legged exercises. The duration of the WBV program was a maximum of 30 minutes, which included warming up (10 min) and cooling down (5 min). All unusual or uncomfortable complaints from participants during the WBV treatment were documented. During the training, all participants were under direct supervision by the same instructor and were instructed on how to perform each exercise.

The PS assessment was accomplished by the electronic Biodex Stability System (BBS, Biodex Medical System, Shirley, NY) which designed to measure and training an individual's ability to maintain stability and balance on an unstable platform. As noted, the BBS uses a circular platform that is free to move in the anterior–posterior and medial lateral axes simultaneously. The BBS allows up to 20° of foot platform tilt and calculates three different parameters according to the direction of the deviations from the horizontal plane; the total stability index (OSI), the anterior - posterior index (API) and the medial - lateral index (MLI). The stability of the platform can be varied by adjusting the level of resistance given by the springs under the platform. In this study, a spring resistance level of two (out of eight) was used because the lower the resistance level the less stable the platform and the intention was to represent the dynamic unstable condition.

Before testing, 10 minutes of standard stretching and warm-up procedures were conducted and subjects were given three practice trials to become familiar with the testing procedures. The BBS offers several levels of difficulty from L1 (unstable) to L12 (stable), which determine the rate of deflection of the platform. In the present study, subjects were bare footed and tested on a bipedal stance at two levels: levels 8 and 2 representing stable and unstable situations, respectively. The order of the tests was randomly assigned to avoid a learning effect and fatigue. Each level of difficulty was tested twice, preceded by a 30-second practice trial. Pretests and posttests were counterbalanced to minimize the testing effects. A rest period of 2 minutes was given between each level of difficulty. One-way ANCOVA (pretest as covariate) were used to analyze the differences between groups (WBVT group versus control group) on PS parameters: OSI, API and MLI, after WBVT. The level of significance difference was set at $p < .05$. An alpha level of .05 was used to determine the significance level for all analyses. Statistical analyses were conducted in Statistical Package for Social Science for Microsoft Windows, version 12.0 (SPSS Inc, Chicago, Ill, US).

RESULTS: Statistical analysis demonstrated that the improvement of PS in the WBVT group was significantly greater than that in the control group after 8 weeks of training. In addition, significant difference were also founded between pretest and post-test in the WBVT group in each testing condition which the O, AP, and ML stability index significant decreased in the level 2 (unstable, figure 1, * represented significant differences between groups) and the O and ML stability index significant decreased in the level 8 (stable, figure 2).

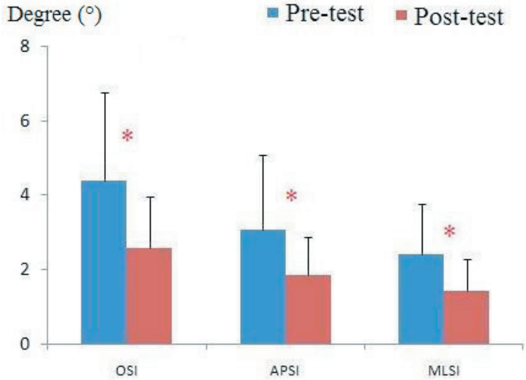

Figure 1: PS Performance in the WBVT group before and after training at Level 2.

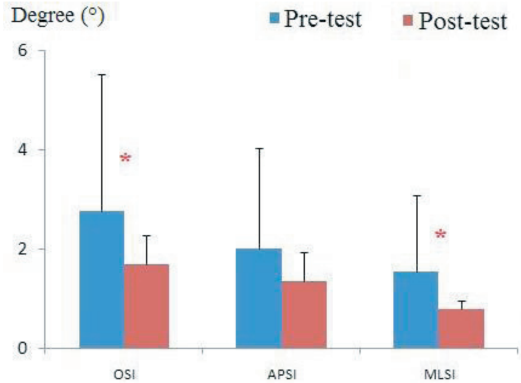

Figure 2: PS Performance in the WBVT group before and after training at Level 8.

DISCUSSION: Whole body vibration (WBV) is a new kind of somatosensory stimulus and was reported to improve vertical jumping height and muscular contractile properties in healthy young subjects. However, the beneficial effects of WBVT on PS are still controversy; some results have supported a positive effect (Bogaerts, et al. 2006) while others (Torvinen, et al, 2002) had no effect on the dynamic or static balance of the young subjects for several months of treatment. The principal finding of this study was demonstrated the positive effect of WBVT in PS which showed that significant improve the performance of stable and unstable conditions in the elderly.

The nature of this repetitive stimulation might be a rearrangement of balance control strategies, which results in improvement of PS after regular WBVT. The results of this study showed significant improvements in the indices of PS (O, AP and ML stability index) after training in the WBVT group, especially in the level 2, unstable testing condition. This finding is in agreement with the results of authors who studied the positive effects of vibration in patients' balance (Bogaerts, et al. 2006; Schuhfried, et al, 2005). This might be due to positive effects of WBVT on muscle strength, improved synchronization of firing of the motor units and improved co-contraction of synergist muscles, which could bring about better PS strategies (Jordan, et al., 2005; Van Nes, et al., 2005).

It has also been suggested that WBVT can stimulate the extroceptive receptors on the sole of the foot (Merkel, Meissner, and Ruffini receptors), that lead to physiological changes at numerous levels including stimulation of skin receptors, muscle spindles, joint mechanoreceptors, and changes in neurotransmitter and hormone concentrations which can affect muscle strength, muscle power, body balance, neuromuscular conditions. Furthermore, other mechanistic findings indicate that WBVT induces underlying neural and muscular changes, such as stimulation of human spindle endings, and changes in biogenic amines, which should help to enhance the balancing ability.Moreover, in this study it was noted that WBVT was a very pleasant experience for all participants, and the acceptance of the program by all participants of the WBVT group was encouraging.

CONCLUSION: Eight-week WBVT can improve the PS in the elders, not only in the medial-lateral directions during stable condition, but also in the anterior-posterior directions during unstable condition.

REFERENCES:

Bogaerts, A., Verschueren, S., Delecluse, C., et al. (2007). Effects of whole body vibration training on postural control in older individuals: a 1 year randomized control trail. *Gait & Posture*, 26, 309-316.

Cardinale, M. & Lim, J. (2003). Electromyography activity of vastus lateralis muscle during whole-body vibrations of different frequencies. *Journal of Strength and Conditioning Research*, 17, 621-624.

Furness,T.P. & Maschette, W.E. (2009). Influence of whole body vibration platform frequency on neuromuscular performance of community-dwelling older adults. *Journal of Strength and Conditioning Research*, 23. 1508-1513.

Jordan, M.J., Norris, S.R., Smith, D.J., et al. (2005). Vibration training: an overview of the area, training consequences, and future consideration. *Journal of Strength and Conditioning Research*, 19, 459-466.

Lee, A.J.Y. & Lin, W.H. (2007). The influence of gender and somatotype on single-leg upright standing postural stability in children. *Journal of Applied Biomechanics*, 23, 173-179.

Lee, A.J.Y. & Lin, W.H. (2008). Twelve-week biomechanical ankle platform system training on postural stability and ankle proprioception in subjects with unilateral functional ankle instability. *Clinical Biomechanics*, 23, 8, 1065-1072.

Schuhfried, O., Mittermaier, C., Jovanovic, T., et al. (2005). Effects of whole body vibration training in patient with multiple sclerosis. *Clinical Rehabilitation*,19, 834-842.

Torvinen, S., Kannu, P., Sievanen, H., et al. (2002). Effects of four-month vertical whole body vibration on performance and balance. *Medicine & Science in Sports & Exercise*, 34, 1532-1538.

Van Nes, I., Geurts, A.C.H., Alexander, C.H., et al. (2005). Short term effects of whole body vibration on postural control in unilateral chronic stroke patients: preliminary evidence. *American Journal of Physical Medicine & Rehabilitation*, 83, 867-873.

Acknowledgement
This research was supported by grants from Sports Affairs Council and National Science Committee, Executive Yuan, TAIWAN, R.O.C.